BISTRIȚA RIVER CHANNEL CHANGES IN THE SUBCARPATHIAN SECTOR, IN THE LAST TWO CENTURIES

***D-.A. CHELARU*[1]*, I. MINEA*[1]**

ABSTRACT. - Bistrița river channel changes in the subcarpathian sector, in the last two centuries. Over time, the hydrographic network corresponding to Bistrița basin has undergone numerous changes, mostly human induced, materialized through the hydrotechnical works made in order to create accumulation lakes (especially after 1960, to encrease electricity production), regularization, damming and embankment, land reclamation or achievement of adduction related to public water supply, and also for built-up area or transport routes network expansion. These actions have led to significant changes regarding the hydrographic network morphometry, by reducing the length of the river, degreasing slopes or sinuosity index. The succesion of changes was analyzed by using the following cartographic documents: Austrian maps published by von Otzellowitz (1788-1790), topographic maps (1:50.000 scale) published in 1894, military maps (1:20.000 scale) edited in 1917-1920, topographic plans (1:5.000 scale), 1975-1976 edition, cadastral plans printed in 1986 (1:10.000 scale) and 2005-2006 ortophotomaps at 1:5.000 scale. Overlapping these maps using GIS techniques highlighted the significant reduction of unplaite and sinuosity index. Also, following the deviation of the natural course of Bistrița river through the creation of a 30 kilometers drainage channel were brought important changes to the river channel morphometry, to the position and river confluences angles, and to the whole hydrographic network of the subcarpathian sector of this river.

Keywords: channel changes, human intervention, Bistrița subcarpathian sector.

1. INTRODUCTION

The modifications of the river beds thanks to the vertical instability along the longitudinal profile have numerous negative effects, such as: putting in danger bridges, dikes, and other hydro technical constructions, evacuations of large volumes of sediments; damage produced to the aquatic and riparian ecosystems, losses of the habitation diversity, effects on the relation between river and the groundwaters, damages brought to the riparian vegetation, the growth of the risk of flooding (Rădoane et al, 2010).

This study proposes, besides the quantification of the elements related to each type of river channel, also the establishment of some causal connections both at the level of the analyzed components and between them and the exterior factors (Floroiu, 2011). River channel represents the most recent form of fluvial landscape, which continues to be shaped by Bistrița river, through erosion and

[1] "Alexandru Ioan Cuza" University, Faculty of Geography and Geology, 700505, Iasi, Romania, e-mail: chelarudanadrian@yahoo.com

alluvial processes. The anthropic interventions on the river, particularly through the hydrotechnical works realised for energetic purposes have led to complete modification of riverbed modeling conditions, so as the direction of evolution has been changed on the whole river course.

The river channel dynamics is highlighted the best on a small scale, by the analysis of river sectors. Another important aspect is the classification of river channels, in relation to the plan configuration of river, being distinguished three main types: rectilinear, sinuous and braided river channels (Leopold și Wolman, 1964, cited by Ionus, 2011).

Bistrița river is located in northeast of the country, with a total length of 283 kilometers and a basin area of 7039 square kilometers. The river sector that we analyzed identifies with the subcarpathian depressionary unit, where the Bistrița plain is well delimited on the field by the terraces of 10-15, 15-20 and 35-40 meters, which are poorly affected by geomorphological processes. Entering the subcarpathian sector, the river channel mobility is higher, the main course changing its position after each flood, being facilitated by numerous mining gravel from the riverbed and surrounding areas. The existence of this rich source of water in the area under study was an essential prequisite for the emergence and development of settlements, the high potential of this resource being fully exploited through hydrotechnical works.

2. DATA AND METHODS

In order to identify river network dynamics of Bistrița for the subcarpathian sector, were used a succesion of maps from relevant time periods: austrian maps published by von Otzellowitz from 1788-1790 (1:56.000 scale), military maps (1:20.000 scale) edited in 1917-1920, topographic plans (1:5.000 scale), 1975-1976 edition and 2005-2006 ortophotomaps (1:5.000 scale), all scanned and then imported into TNT Mips 7.2 software and the same projection type (Stereo 70). Final processing of cartographic materials was achieved through Corel Draw X4 graphics program. Based on these maps, we tried to capture the main changes occurred over time by analyzing the hydrographic branches in terms of meandering, the existence of secondary or abandoned courses, the presence of river banks, regularization of certain river sectors etc.

Obviously, due to different scales of maps achievement, have appeared a series of errors, but the watercourses length measured on maps, given that the area is sub-mountainous, represents the cathetus of a right triangle. In this case, to determine the length (L) as close to reality, is used the length of cartographic projection of the course (L_c), reported to the cosine of angle slope (α) (Sorocovschi, 2003):

$$L = \frac{L_c}{\cos\alpha}$$

In morphometric terms, the analysis of hydrographic network changes was based on utilizing two coeficients: Sinuosity index (C_s) and Ramification index (C_r) of the rivers (Minea, Romanescu, 2007).

Sinuosity index of rivers (C_s) is the ratio of the actual length of the river (L_r) and the straight line length between the source and shedding (L). The causes of river sinuosity are related primarily to the river channel hidraulics and the interaction between the resistance of slopes and river channel dynamics, to the tectonic factors and also the changes induced by the hydrotechnic works undertaken (Schram, Pantazică, 1984).

The sinuosity index is always above par and is calculated according to the formula:

$$C_s = \frac{L_r}{L_d}; \; C_s > 1$$

Ramification index (C_r). If a river presents an unplaite of the main course in several branches, these are joining, from place to place, creating the river unplaite (ramifications).

This ramification occurs due to very small slope of the river channel, crossing a relief unit to another, as it is the case of the subcarpathian sector of Bistrița river, to watercourse speed reduction, transport power reduction, river alluvial flow etc. Between river ramificationss are forming levees, permanent isles and temporary sand banks.

To estimate this coefficient is necessary to measure all branches (l_1, l_2, l_3,….l_n), their summation and report the value obtained to the main stream lentgh (L_p) (Gâştescu et al., 2002):

$$C_r = \frac{\Sigma l_i}{L_p}$$

3. RESULTS AND DISCUSSIONS

Bistrița, the only river that crosses through a mountainous region over a 200 km distance, has undergone major changes by human influence, who deviated its course on a length of over 30 km, for hydroelectric purposes. The subcarpathian sector, it appears to have an meandered course on the old maps, with many secundar branches, numerous coastlands and extensive wetland and marshy areas. All these elements will be subject to change due to regularization and planning works undertaken. Thus, the recent maps record adjustments of the river course, disappearance of side branches, coastlands and many marshy areas due to construction of drainage systems.

Until the hydropower system which started to be developed in 1960 (whose targets range from Izvorul Muntelui lake – Bicaz dam to Bacău), Bistrița river acted as a genuine communication artery of which depended the economic life of the entire territory. On Bistrița were coming rafts that provided the raw material necessary for lumber and paper mills and also represented a safe connection way with Bacău and Danube ports.

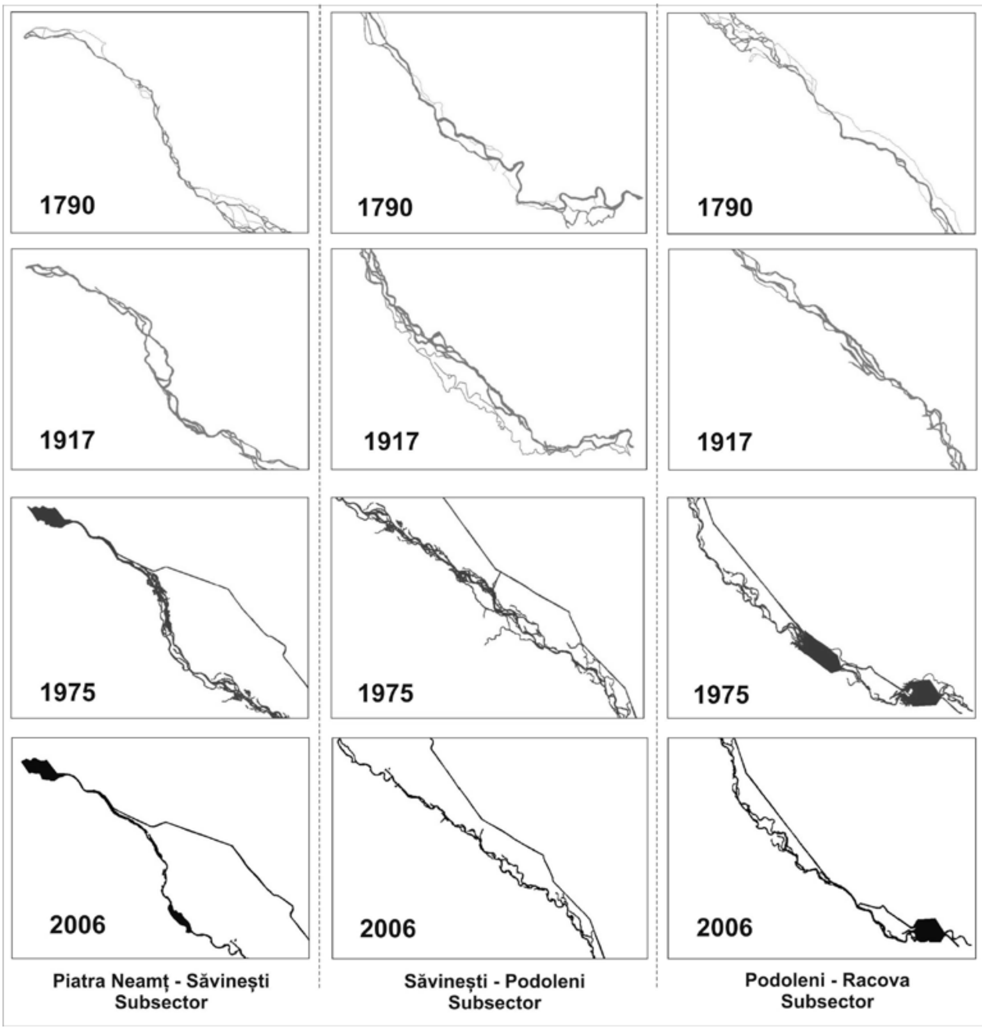

Fig. 1. ***Changing the overall configuration of Bistrița riverchannel in the subcarpathian sector***

After building the Bicaz accumulation lake and putting into service of the entire hydropower system, the economic role and the appearance of Bistrița has changed. Rafts disappeared, were created hydropower plants as a clean energy source, the waterflow variations were not like in the past, appeared new accumulation lakes and dams that completely change the aspect of Bistrița river channel. The planning works of Bistrița river favored especially the socio-economic development of the territory.

The most obvious dynamics is related to river channel parameters (fig. 1). The biggest changes of Bistrița river channel occured during high waters and floods, as a result of significant flow quantities transiting the riverbed in a relatively short time unit. Transited flows had large fluctuations, during these events, which also occur at very irregular intervals (Bocoi, 2009).

The river channel morphology is diverse, being generally well individualized, having widths from few to over 50 meters. There is a pronounced tendency of river channel unplaite starting from entering the flych, but this unplaite is maximal in extra-carpathian sector, where it reaches 5,6 degree, caused by sediment overload as a result of intense water infiltration (Donisă, 1968).

In order to quantify the changes of Bistrița river channel configuration in the subcarpathian sector, we extracted the morphometric information by processing the four series of cartographic documents used. Following the completion of calculations resulted two charts in which are shown the morphometric variables coresponding to each period analyzed. We considered useful in achieving the goal of the paper the representation of sinuosity (fig. 2) and ramification coefficients (fig. 3), on which analysis we can establish some causal relations regarding river channel changes. A first observation is related to the high morphometric variability of Bistrița alluvial plain in longitudinal profile.

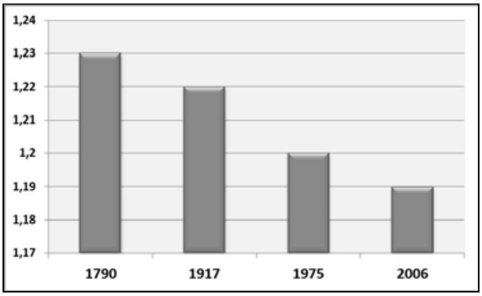

Fig. 2. ***Sinuosity index***

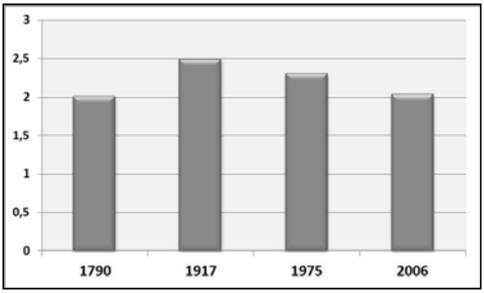

Fig. 3. ***Ramification index***

For the first set of the processed maps, respective the austrian maps made in 1788/1790, due to their smaller scale (1:56.000) can be found some errors induced by the way of achieving the maps which is reflected in high values of sinuosity index (1,23) and low values for ramification index (2,01). Certainly a number of secondary branches of the river were not mapped, and thus they couldn't be taken into account when determining the ramification coefficient.

Larger scale of the military maps realised at the beginning of 20th century allowed us a better determination of these coefficients. It shows a large increase of ramification coefficient value (2,49) given by higher accuracy of the maps.

As for implementation of numerous hydrotechnical works, in Bistrița subcarpathian sector can be noted for the year 1975 that the sinuosity index values decreases, reaching 1,20. In the case of ramification factor, due to the large scale of the topographic plans (1:5.000), the high values resulted are not entirely reflecting the reality (2,31).

The analysis of the orthophotomaps carried out during 2005/2006 showed that the ramification index values are decreasing (2,04) as an effect of hydrotechnical works remanence and reforms in land use, especially after 1990.

Depending on the specific conditionings, of natural or anthropic type, dynamic fluvial processes, resulting morphology and spatial restructuring forms differ in an obvious manner from one sector to another (Petre et al., 2006). One can identify changes over time in terms of river channel typology on different sectors.

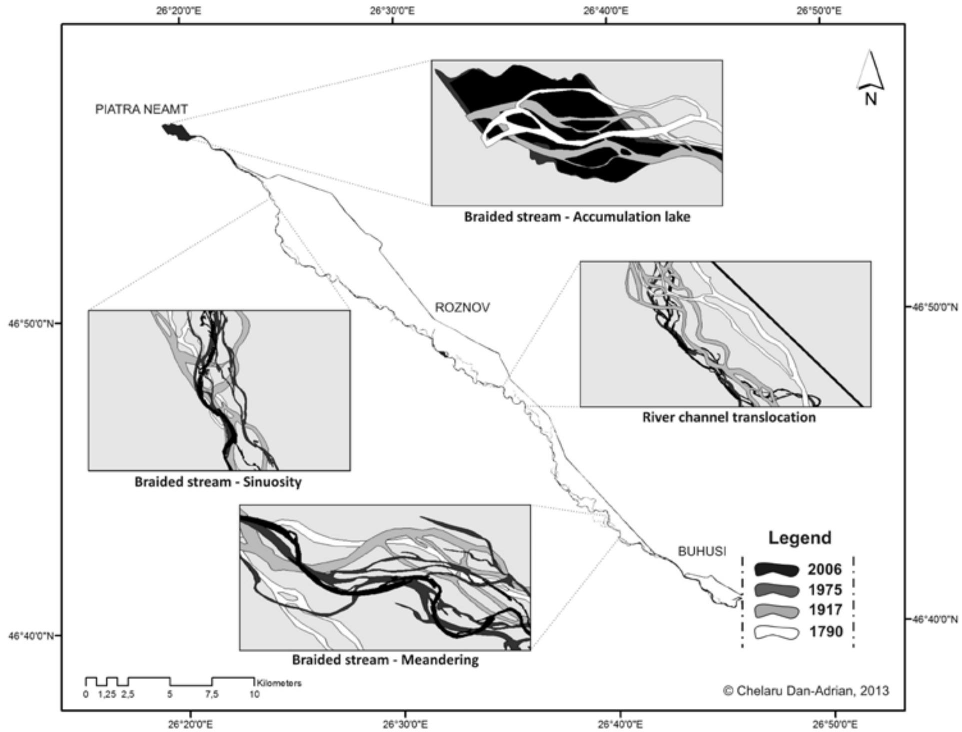

Fig. 4. ***Evolution of river channel typology of Bistrița subcarpathian sector. Analysis by samples***

The above figure highlights, through a series of representative samples, different types of river channel evolution characterized by its translocation at Podoleni, the evolution from a braided to a sinuous course (Dumbrava Roșie) or meandered (at Buhuși), or transforming a river sector into accumulation lake (eg Piatra Neamț).

Fig. 5. ***(1) Bistrița river at Roznov – braided riverbed; (2) Deviation channel at Podoleni; (3) Hydropower plant at Costișa***

4. CONCLUSIONS

The evolution of Bistrița river in the subcarpathian sector is influenced by natural environmental changes, and especially by human interventions that have had a great impact on the overall configuration and river channel functionality. Besides the benefic socio-economic effects, river channel changes due to anthropic factor causes a series of imbalances to the hydrosystem functionality by reducing liquid and solid fluxes with negative repercussions at territorial level.

Given the high degree of natural resources exploitation associated to the fluvial landscape in subcarpathian sector of Bistrița valley, are required a series of appropriate measures for the optimum management of river natural dynamics.

Although the river channel geometry is very sensitive to anthropic changes, it appears that the evolution trend of Bistrița river in subcarpathian sector remained the same, creating and developing meanders, even if the pace has dimished.

Acnowledgements

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REFERENCES

1. Bocoi Liliana., (2009), V*alea Crasnei. Dimensiunea geomorfologică în contextul utilizării terenului*, PhD thesis summary, Oradea.
2. Donisă I., (1968), *Geo-morfologia Văii Bistriței*, Edit. Academiei Socialiste Române, Bucuresti.
3. Floroiu I., (2011), *Types of riverbed along the Lower Course of the Buzau River*, in Forum Geographic, vol. 10, no. 1, 91-98.
4. Gâştescu, P., Murarescu, O., Dinu, I., Bretcan, P., (2002), *Hidrologie continentala*, Edit. Roza Vânturilor, Târgovişte.
5. Ionuș Oana, (2011), *Potențialul geoecologic al apelor de suprafață în bazinul hidrografic Motru*, PhD thesis summary, București.

6. Minea I., Romanescu Gh. (2007), *Hidrologia mediilor continentale. Aplicaţii practice*, Casa Editorială Demiurg, Iaşi.
7. Petrea D., Rus I., Petrea R., (2006), *Restructurari plan-spațiale în evoluția recentă a albiei Crișului Repede,* Revista de Geomorfologie, vol. 8, 35-44.
8. Rădoane Maria, Pandi, G., Rădoane, N. (2010), *Contemporary bed elevation changes from the Eastern Carpathians,* Carpth. J. of Earth and Environmental Sciences, vol.3, No.3, 13 –38.
9. Schram, Maria, Pantazică, Maria, (1983), *Hidrologia uscatului,* Universitatea „Al.I.Cuza", Iaşi.
10. Sorocovschi, V., (2003), *Hidrologia uscatului*, Edit. Casa cărţii de Ştiinţă, Cluj-Napoca.